# D E C L A R A T I O N

I, Hideki OMOTE, a national of Japan, c/o Sumitomo Chemical Intellectual Property Service, Limited, 5-33, Kitahama 4-chome, Chuo-ku, Osaka-shi, Osaka 541-8550, Japan, declare that to the best of my knowledge and belief the attached is a full, true and faithful translation into English made by me of the certified copy of Japanese Patent Application No. Heisei 11-370664 attached thereto.

Signed this 22nd day of October, 2004

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[Title of the Invention] Catalyst for $\alpha$-olefin polymerization and process for producing $\alpha$-olefin polymer

[Scope of Claims for Patent]

[Claim 1]

A catalyst for $\alpha$-olefin polymerization obtained by contacting (A), (B) and (C) described below:

(A) an organoaluminum compound,

(B) one or more of boron compounds selected from (C1) to (C3) below;

(B1) a boron compound represented by the general formula $BQ^1Q^2Q^3$,

(B2) a boron compound represented by the general formula $G^+(BQ^1Q^2Q^3Q^4)^-$, and

(B3) a boron compound represented by the general formula $(L\text{-}H)^+(BQ^1Q^2Q^3Q^4)^-$

(wherein B is a boron atom, $Q^1$ to $Q^4$ are a halogen atom, a hydrocarbon group, a halogenated hydrocarbon group, a heterocyclic group, a substituted silyl group, an alkoxy group, or a di-substituted amino group, and they may be the same or different. $G^+$ is an inorganic, organic or organometallic cation. L is a neutral Lewis base, and $(L\text{-}H)^+$ is a Brϕnsted acid.), and

(C) a solid inorganic compound.

[Claim 2]

The catalyst for $\alpha$-olefin polymerization according to claim 1, wherein the organoaluminum compound is one or more of aluminum compounds selected from (A1) to (A4) below:

(A1) An organoaluminum compound represented by the general formula; $R_rAl(OR)_oH_pX^1{}_q$ ;

(A2) an organoaluminum compound represented by the general formula; $M^1AlR_4$;

(A3) a cyclic aluminoxane having a structure represented by the general formula; $\{-Al(R)-O-\}_j$ ; and

(A4) an aluminoxane having a structure represented by the general formula; $R\{-Al(R)-O-\}_k\ AlR_2$

(wherein each of R's independently represents a hydrocarbon group having 1 to 20 carbon atoms; each of $X^1$'s independently represents a halogen atom; $M^1$ represents an alkaline metal atom; "r" represents a numeral satisfying $0 < r \leqq 3$; "o" represents a numeral satisfying $0 \leqq o < 3$; "p" represents a numeral satisfying $0 \leqq p < 3$; "q" represents a numeral satisfying $0 \leqq q < 3$; $r + o + p + q = 3$; "j" represents an integer of 2 or more; and "k" represents an integer of 1 or more.)

[Claim 3]

The catalyst for $\alpha$-olefin polymerization according to claim 1 or 2, wherein the solid inorganic compound (C) is a compound selected from the group consisting of metals of the Groups 1 to 3 and 6 to 16 of the Periodic Table of the Elements.

[Claim 4]

The catalyst for $\alpha$-olefin polymerization according to claim 1 or 2, wherein the solid inorganic compound is a Brϕnsted acid salt.

[Claim 5]

The catalyst for $\alpha$-olefin polymerization according to claim 1 or 2, wherein the solid inorganic compound is a halogenated metal compound.

[Claim 6]

The catalyst for an $\alpha$-olefin polymerization according to any one of claims 1 to 5, wherein the catalyst for an $\alpha$-olefin polymerization is a catalyst for stereoregular $\alpha$-olefin polymerization.

[Claim 7]

A process for producing an $\alpha$-olefin polymer, which comprises using the catalyst for $\alpha$-olefin polymerization of any one of claims 1 to 6.

[Claim 8]

The process according to claim 7, wherein the $\alpha$-olefin polymer is an $\alpha$-olefin polymer having an isotactic diad fraction [mm] of more than 0.25.

[Detailed Description of the Invention]

[0001]

[Technical Field To Which the Invention Belongs]

The present invention relates to a catalyst for $\alpha$-olefin polymerization and a process for producing an $\alpha$-olefin polymer.

[0002]

[Prior Art]

It is known that a polyethylene is obtained by contacting ethylene with an alkylaluminum which has been used as a co-catalyst in "Angew. Chem. Vol.64, pp323 (1952)" and "Makromol. Chem. Vol.193, pp1283 (1992)".

Further, Reports relating to an addition polymerization using an aluminum complex as a catalyst have been known in "J. Am. Chem. Soc. Vol.119, pp8125 (1997)", "J. Am. Chem. Soc. Vol.120, pp8277(1998)", "Chem. Commun., pp2523 (1998)", a specification of International Application WO98/40421.

[0003]

With respect to a polymerization of an $\alpha$-olefin such as propylene or the like, a process for producing a propylene polymer with a catalyst in which an organoaluminum compound is supported on a carrier, is also known. Examples of such as catalyst have been disclosed in JP-A-52-2890 as an example of being supported on a metal acetate, and "Polymer Preprints, Japan, Vol.46, pp216 (1997)" and "Polymer Preprints, Japan, Vol.46, pp1215(1997)" as an example of being supported on a metal chloride.

[0004]

[Problem to be solved by the Invention]

However, these catalysts for $\alpha$-olefin polymerization have been not always satisfied from the viewpoint of catalyst activity.

In view of the above-situations, a subject of the present invention, namely, an object is to provide catalyst for $\alpha$-olefin polymerization showing a highly polymerization activity, and a process for producing efficiently an $\alpha$-olefin polymer.

[0005]

[Means for solving the Problem]

Namely, the present invention relates to a catalyst for

$\alpha$-olefin polymerization obtained by contacting (A), (B) and (C) described below, and to a process for producing an $\alpha$-olefin polymer with the catalyst:

(A) an organoaluminum compound,

(B) one or more of boron compounds selected from (C1) to (C3) below;

(B1) a boron compound represented by the general formula $BQ^1Q^2Q^3$,

(B2) a boron compound represented by the general formula $G^+(BQ^1Q^2Q^3Q^4)^-$, and

(B3) a boron compound represented by the general formula $(L\text{-}H)^+(BQ^1Q^2Q^3Q^4)^-$.

(wherein B is a boron atom, $Q^1$ to $Q^4$ are a halogen atom, a hydrocarbon group, a halogenated hydrocarbon group, a heterocyclic group, a substituted silyl group, an alkoxy group, or a di-substituted amino group, and they may be the same or different. $G^+$ is an inorganic, organic or organometallic cation; L is a neutral Lewis base, and $(L\text{-}H)^+$ is a Brφnsted acid.), and

(C) a solid inorganic compound.

The present invention is illustrated in detail below.

[0006]

[Mode of Practicing the Invention]

(A) Organoaluminum compound

The organoaluminum compound used in the present invention is an aluminum compound having an Al-C bond. Various such as aluminum compounds can be used, and one or more of aluminum compounds selected from (A1) to (A4) described below

are preferable:

(A1) An organoaluminum compound represented by the general formula; $R_rAl(OR)_oH_pX^1_q$ ,

(A2) an organoaluminum compound represented by the general formula; $M^1AlR_4$,

(A3) a cyclic aluminoxane having a structure represented by the general formula; $\{-Al(R)-O-\}_j$ , and

(A4) a linear aluminoxane having a structure represented by the general formula; $R\{-Al(R)-O-\}_k AlR_2$,

wherein each of R's independently represents a hydrocarbon group having 1 to 20 carbon atoms; each of $X^1$'s independently represents a halogen atom; $M^1$ represents an alkaline metal atom; "r" represents a numeral satisfying $0 < r \leqq 3$; "o" represents a numeral satisfying $0 \leqq o < 3$; "p" represents a numeral satisfying $0 \leqq p < 3$; "q" represents a numeral satisfying $0 \leqq q < 3$; $r + o + p + q = 3$; "j" represents an integer of 2 or more; and "k" represents an integer of 1 or more.

[0007]

As the organoaluminum compound (A1), the following compounds and the like can be exemplified.

① An organoaluminum compound represented by the general formula; $R_rAl(OR)_{3-r}$

(in the general formula, each of R's independently represents a hydrocarbon group having 1 to 20 carbon atoms, preferably 1 to 15 carbon atoms, and more preferably 1 to 8 carbon atoms. "r" represents a numeral satisfying $0 < r \leqq 3$, and preferably $1 \leqq r \leqq 3$.)

② An organoaluminum compound represented by the general formula; $R_rAlX^1_{3-r}$

(in the general formula, each of R's independently represents a hydrocarbon group having 1 to 20 carbon atoms, preferably 1 to 15 carbon atoms, and more preferably 1 to 8 carbon atoms, and each of $X^1$'s independently represents a halogen atom. "r" represents a numeral satisfying $0 < r \leqq 3$, and preferably $0 < r < 3$.)

③ An organoaluminum compound represented by the general formula; $R_rAlH_{3-r}$

(in the general formula, each of R's independently represents a hydrocarbon group having 1 to 20 carbon atoms, preferably 1 to 15 carbon atoms, and more preferably 1 to 8 carbon atoms. "r" represents a numeral satisfying $0 < r \leqq 3$, and preferably $2 \leqq r < 3$.)

④ An organoaluminum compound represented by the general formula; $R_rAl(OR)_oX^1_q$ ,

(in the general formula, each of R's independently represents a hydrocarbon group having 1 to 20 carbon atoms, preferably 1 to 15 carbon atoms, and more preferably 1 to 8 carbon atoms, and each of $X^1$'s independently represents a halogen atom. "r" represents a numeral satisfying $0 < r \leqq 3$, "o" represents a numeral satisfying $0 \leqq o < 3$, "q" represents a numeral satisfying $0 \leqq q < 3$, and $r + o + q = 3$.

Each of R's in the general formula representing the above-mentioned organoaluminum compounds ① to ④ is independently an alkyl group or an aryl group, and each of $X^1$'s is independently a chlorine atom or a bromine atom.

[0008]

Specific examples of the organoaluminum compound of the fore-mentioned ① include tri-n-alkylaluminums such as trimethylaluminum, triethylaluminum, tri-n-butylaluminum, tri-n-hexylaluminum, tri-n-octylaluminum and the like; tri branched-alkyl aluminums such as triisopropylaluminum, triisobutylaluminum, tri-sec-butylaluminum, tri-tert-butylaluminum, tri-2-methylbutylaluminum, tri-3-methylbutylaluminum, tri-3-methylpentylaluminum, tri-4-methylpentylaluminum, tri-2-methylhexylaluminum, tri-3-methylhexylaluminum, tri-2-ethylhexylaluminum and the like; tricycloalkylaluminums such as tricyclohexylaluminum and the like; triarylaluminums such as triphenylaluminum, tritolylaluminum and the like; trialkenylaluminums such as triisoprenylaluminum and the like; alkylaluminum dialkoxides such as isobutylaluminum dimethoxide, isobutylaluminum diethoxide, isobutylaluminum diisopropoxide and the like; dialkylaluminum alkoxides such as diethylaluminum ethoxide, dibutylaluminum butoxide and the like; alkylaluminum sesquialkoxides such as ethylaluminum sesquibutoxide, butylaluminum sesquibutoxide and the like; alkylaluminums whose alkyls are partially replaced with aryloxy group such as methylaluminum bis(2,6-di-tert-butyl-4-methylphenoxide), ethylaluminum bis(2,6-di-tert-butyl-4-methylphenoxide) and the like; partially alkoxylated alkylaluminums which have a mean composition in which r in the general formula representing

the organoaluminum compound of the fore-mentioned ① is 2.5; etc.

[0009]

Specific examples of the organoaluminum compound of the fore-mentioned ② include alkylaluminum sesquihalides such as ethylaluminum sesquichloride, butylaluminum sesquichloride, ethylaluminum sesquibromide and the like; dialkylaluminum halides such as dimethylaluminum chloride, diethylaluminum chloride, dipropylaluminum chloride, diisobutylaluminum chloride, dihexylaluminum chloride, butylaluminum bromide and the like; alkylaluminum dihalides such as methylaluminum dichloride, ethylaluminum dichloride, propylaluminum dichloride, isobutylaluminum dichloride, hexylaluminum dichloride, octylaluminum dichloride, butylaluminum dibromide and the like; etc.

[0010]

Specific examples of the organoaluminum compound of the fore-mentioned ③ include dialkylaluminum hydrides such as diethylaluminum hydride, dibutylaluminum hydride, diisobutylaluminum hydride and the like; alkylaluminum dihydrides such as ethylaluminum dihydride, propylaluminum dihydride and the like; alkylaluminums whose alkyl is partially substituted with hydrogen.

[0011]

Specific examples of the organoaluminum compound of the fore-mentioned ④ include alkylaluminums which are partially alkoxylated and halogenated, etc.

[0012]

The fore-mentioned organoaluminum compound (A2) is an organoaluminum compound represented by the general formula; $M^1AlR_4$. Herein, $M^1$ represents an alkaline metal atom. The alkaline metal atom is preferably a lithium atom, a sodium atom or a potassium atom, and preferably a lithium atom in particular. The organoaluminum compound (A2) is preferably $LiAl(C_2H_5)_4$ or $LiAl(C_7H_{15})_4$ in particular.

[0013]

As specific examples of R in a cyclic aluminoxane (A3) having the general formula; $\{-Al(R)-O-\}_j$ and a linear aluminoxane (A4) having the general formula; $R\{-Al(R)-O-\}_k AlR_2$, can be exemplified alkyl groups such as a methyl group, an ethyl group, a n-propyl group, an isopropyl group, a n-butyl group, an isobutyl group, a n-pentyl group, a neopenyl group and the like. "j" is an integer of 2 or more and "k" is an integer of 1 or more. R is preferably a methyl group or an isobutyl group, j is 2 to 40, and k is 1 to 40.

[0014]

The above-mentioned aluminoxanes are prepared by various methods. The procedure is not particularly restricted, and they may be prepared according to well-known methods. For example, they are prepared by contacting a solution of a trialkylaluminum(for example, trimethylalumnum and the like) in a suitable organic solvent (aromatic hydrocarbon; e.g. benzene, aliphatic hydrocarbon; e.g. hexane; and the like with water. Further, a method for preparing the aluminoxanes by contacting trialkylaluminum (e.g. trimethylaluminum) with a metal salt containing water of crystallization (e.g. cupric

sulfate hydrate) can be exemplified. It is considered that the aluminoxanes thus obtained are usually a mixture of (A3) and (A4).

[0015]

The organoaluminum compound used in the present invention is preferably the above-mentioned organoaluminum compound (A1), further preferably the above-mentioned organoaluminum compound ①, preferably a trialkylaluminum in particular among them, and most preferably trimethylaluminum, triethylaluminum, triisobutylaluminum, tri-n-hexylaluminum or tri-n-octylaluminum.

[0016]

(B) Boron compound

As the boron compound (B) used in the present invention, at least one compound selected from the group consisting of boron compounds (B1) represented by the general formula $BQ^1Q^2Q^3$, boron compounds (B2) represented by the general formula $G^+(BQ^1Q^2Q^3Q^4)^-$ and boron compounds (B3) represented by the general formula $(L-H)^+(BQ^1Q^2Q^3Q^4)^-$ can be used.

[0017]

In the boron compound(B1) represented by the general formula $BQ^1Q^2Q^3$, B represents a boron atom in the trivalent state; $Q^1$ to $Q^3$ are respectively a halogen atom, a hydrocarbon group, a halogenated hydrocarbon group, a substituted silyl group, an alkoxy group or a di-substituted amino group and they may be the same or different. Each of $Q^1$ to $Q^3$ is preferably a halogen atom, a hydrocarbon group having 1 to 20 carbon atoms, a halogenated hydrocarbon group having 1 to 20 carbon

atoms, a substituted silyl group having 1 to 20 carbon atoms, an alkoxy group having 1 to 20 carbon atoms or a di-substituted amino group having 2 to 20 carbon atoms, and each of more preferable $Q^1$ to $Q^3$ is a halogen atom, a hydrocarbon group having 1 to 20 carbon atoms or a halogenated hydrocarbon group having 1 to 20 carbon atoms. Each of the more preferable $Q^1$ to $Q^3$ is a fluorinated hydrocarbon group having 1 to 20 carbon atoms which contains at least one fluorine atom, and in particular, each of $Q^1$ to $Q^3$ is preferably a fluorinated aryl group having 6 to 20 carbon atoms which contains at least one fluorine atom.

[0018]

Specific examples of the compound (B1) include tris(pentafluorophenyl)borane, tris(2,3,5,6-tetrafluorophenyl)borane, tris(2,3,4,5-tetrafluorophenyl)borane, tris(3,4,5-trifluorophenyl)borane, tris(2,3,4-trifluorophenyl)borane, phenylbis(pentafluorophenyl) borane and the like, and tris(pentafluorophenyl)borane is most preferable.

[0019]

In the boron compound (B2) represented by the general formula $G^+(BQ^1Q^2Q^3Q^4)^-$, $G^+$ is an inorganic or organic cation; B is a boron atom in the trivalent -state; and $Q^1$ to $Q^4$ are the same as defined in $Q^1$ to $Q^3$ in the above-mentioned (B1).

[0020]

Specific examples of $G^+$ as the inorganic cation in the compound represented by the general formula $G^+(BQ^1Q^2Q^3Q^4)^-$

include inorganic cations such as a lithium cation, sodium cation, potassium cation, silver cation and the like, and organometallic cations such as a ferrocenium cation, an alkyl-substituted ferrocenium cation and the like, and as the organic cation, a tetraalkylphosphonium cation, tetraarylphosphonium cation, tetraalkylammonium, trialkylsulfonium cation, diaryliodonium cation, trialkylcarbenium cation and the like are illustrated. $G^+$ is preferably a carbenium cation, and a triphenylcarbenium cation is particularly preferred. As the $(BQ^1Q^2Q^3Q^4)^-$, tetrakis(pentafluorophenyl)borate, tetrakis(2,3,5,6-tetrafluorophenyl)borate, tetrakis(2,3,4,5-tetrafluorophenyl)borate, tetrakis(3,4,5-trifluorophenyl)borate, tetrakis(2,3,4-trifluorophenyl)borate, phenyltris(pentafluorophenyl)borate, tetrakis(3,5-bistrifluoromethylphenyl)borate and the like are mentioned.

[0021]

These specific combinations include lithium tetrakis(3,5-bistrifluoromethylphenyl)borate, sodium tetrakis(3,5-bistrifluoromethylphenyl)borate, potassium tetrakis(3,5-bistrifluoromethylphenyl)borate, silver tetrakis(pentafluorophenyl)borate, ferrocenium tetrakis(pentafluorophenyl)borate, 1,1'-dimethylferrocenium tetrakis(pentafluorophenyl) borate, tetrabutylphsphonium tetrakis(pentafluorophenyl)borate, tetraphenylphsphonium

tetrakis(pentafluorophenyl)borate, tetramethylammonium tetrakis(pentafluorophenyl) borate,trimethylsulfonium tetrakis(pentafluorophenyl) borate, diphenyliodonium tetrakis(pentafluorophenyl) borate, triphenylcarbenium tetrakis(pentafluorophenyl) borate, triphenylcarbenium tetrakis(3,5-bistrifluoromethylphenyl)borate and the like, and triphenylcarbeniumtetrakis(pentafluorophenyl) borate is most preferable.

[0022]

Further, in the boron compound (B3) represented by the formula $(L\text{-}H)^+(BQ^1Q^2Q^3Q^4)^-$, L is a neutral Lewis base; $(L\text{-}H)^+$ is a Brϕnsted acid; B is a boron atom in the trivalent state; and $Q^1$ to $Q^4$ are the same as $Q^1$ to $Q^3$ in the above-mentioned Lewis acid (B1).

[0023]

Specific examples of $(L\text{-}H)^+$ as the Brϕnsted acid in the compound represented by the formula $(L\text{-}H)^+(BQ^1Q^2Q^3Q^4)^-$ include a trialkyl-substituted ammonium, an N,N-dialkylanilinium, a dialkylammonium, a triarylphosphonium and the like, and examples of $(BQ^1Q^2Q^3Q^4)^-$ include those as previously described.

[0024]

These specific combinations include triethylammonium tetrakis(pentafluorophenyl)borate, tripropylammonium tetrakis(pentafluorophenyl)borate, tri(n-butyl)ammonium tetrakis(pentafluorophenyl)borate, tri(n-butyl)ammonium tetrakis(3,5-bistrifluoromethylphenyl)borate, N,N-dimethylanilinium tetrakis(pentafluorophenyl)borate, N,N-diethylanilinium tetrakis(pentafluorophenyl)borate,

N,N-2,4,6-pentamethylanilinium tetrakis(pentafluorophenyl) borate, N,N-dimethylanilinium tetrakis(3,5-bistrifluoromethylphenyl)borate, diisopropylammonium tetrakis(pentafluorophenyl)borate, dicyclohexylammonium tetrakis(pentafluorophenyl)borate, triphenylphosphonium tetrakis(pentafluorophenyl)borate, tri(methylphenyl)phosphonium tetrakis(pentafluorophenyl)borate, tri(dimethylphenyl)phosphonium tetrakis(pentafluorophenyl)borate and the like, and tri(n-butyl)ammonium tetrakis(pentafluorophenyl)borate or N,N-dimethylanilinum tetrakis(pentafluorophenyl)borate is most preferable.

[0025]

As the boron compound used in the present invention, the boron compound (B2) or (B3) is preferable, and triphenylcarbeniumtetrakis(pentafluorophenyl)borate, tri(n-butyl)ammonium tetrakis(pentafluorophenyl) borate or N,N-dimethylanilinum tetrakis (pentafluorophenyl)borate is most preferable.

[0026]

(C) Solid inorganic compound

When the solid inorganic compound is used in the present invention, the solid inorganic compound is an inorganic compound which is solid at normal temperature under normal pressure, and compounds of a metal selected from the Groups 1 to 3 and 6 to 16 of the Periodic Table of the Elements are preferable and it is more preferable to use a Brϕnsted acid

salt.

[0027]

A metal used in the Brϕnsted acid salt is a metal selected from the Groups 1 to 3 and 6 to 16 of the Periodic Table of the Elements, and specific examples thereof include lithium, beryllium, sodium, magnesium, aluminum, potassium, calcium, scandium, chromium, manganese, iron, cobalt, nickel, copper, zinc, gallium, germanium, rubidium, strontium, yttrium, molybdenum, technetium, ruthenium, rhodium, palladium, silver, cadmium, indium, tin, antimony, cesium, barium, lanthanum, tungsten, rhenium, osmium, iridium, platinum, gold, mercury, thallium, lead, bismuth, polonium, francium, radium, actinium, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, lutetium, thorium, protactinium, uranium, neptunium and the like, and sodium, magnesium, manganese, iron, cobalt or nickel is preferable.

[0028]

Further, the fore-mentioned Brϕnsted acid includes hydrofluoric acid, hydrochloric acid, hydrobromic acid, hydroiodic acid and the like.

[0029]

The metal halide compound is a halide of a metal atom represented by the general formula (1) described below:

$$M^2{}_mX^2{}_n \qquad (1)$$

(wherein $M^2$ represents a metal atom selected from the Groups 1 to 3 and 6 to 16 of the Periodic Table of the Elements and $X^2$ represents a halogen atom. "m" represents a numeral of 1

or more, and "n" represents a product of a valence number of the metal atom and "m".)

[0030]

$M^2$ represents a metal atom selected from the Groups 1 to 6 and 6 to 16 of the Periodic Table of the Elements, and includes a lithium atom, beryllium atom, sodium atom, magnesium atom, aluminum atom, potassium atom, calcium atom, scandium atom, chromium atom, manganese atom, iron atom, cobalt atom, nickel atom, copper atom, zinc atom, gallium atom, germanium atom, rubidium atom, strontium atom, yttrium atom, molybdenum atom, technetium atom, ruthenium atom, rhodium atom, palladium atom, silver atom, cadmium atom, indium atom, tin atom, antimony atom, cesium atom, barium atom, lanthanum atom, tungsten atom, rhenium atom, osmium atom, iridium atom, platinum atom, gold atom, mercury atom, thallium atom, lead atom, bismuth atom, polonium atom, francium atom, radium atom, actinium atom, cerium atom, praseodymium atom, neodymium atom, promethium atoim, samarium, europium atom, gadolinium atom, terbium atom, dysprosium atom, holmium atom, erbium atom, thulium atom, ytterbium atom, lutetium atom, thorium atom, protactinium atom, uranium atom, neptunium atom and the like, and sodium atom, magnesium atom, manganese atom, iron atom, cobalt atom or nickel atom is preferable.

[0031]

$X^2$ in the above-mentioned general formula (1) represents a halogen atom, and specific examples thereof include a fluorine atom, chlorine atom, bromine atom, iodine atom or the like. A chlorine atom, bromine atom or iodine atom is

preferable.

[0032]

Specific examples of the metal halide represented by the above-mentioned general formula (1) include metal fluorides such as zinc(II) fluoride, aluminum fluoride, antimony(III) fluoride, antimony(V) fluoride, yttrium fluoride, iridium(I) fluoride, iridium(II) fluoride, iridium(III) fluoride, iridium(IV) fluoride, iridium(V) fluoride, iridium(VI) fluoride, indium(III) fluoride, uranium(III) fluoride, uranium(IV) fluoride, uranium(V) fluoride, osmium(IV) fluoride, osmium(V) fluoride, osmium(VI) fluoride, cadmium fluoride, gadolinium(III) fluoride, potassium fluoride, gallium(III) fluoride, calcium fluoride, gold(III) fluoride, silver(I) fluoride, silver(II) fluoride, chromium(II) fluoride, chromium(III) fluoride, chromium(IV) fluoride, chromium(V) fluoride, chromium(VI) fluoride, cobalt(II) fluoride, cobalt(III) fluoride, samarium(II) fluoride, samarium(III) fluoride, mercury(I) fluoride, mercury(II) fluoride, scandium fluoride, tin(II) fluoride, tin(IV) fluoride, strontium fluoride, cesium fluoride, cerium(III) fluoride, cerium (IV) fluoride, thallium(I) fluoride, thallium(III) fluoride, tungsten(IV) fluoride, tungsten(V) fluoride, tungsten(VI) fluoride, hexatantalum tetradecylfluoride, hexatantalum pentadecylfluoride, tantalum(III) fluoride, tantalum(IV) fluoride, tantalum(V) fluoride, thulium(III) fluoride, technetium(V) fluoride, technetium(VI) fluoride, iron(II) fluoride, iron(III) fluoride, diiron pentafluoride, copper(I) fluoride,

copper(II) fluoride, thorium(IV) fluoride, sodium fluoride, lead(II) fluoride, lead(IV) fluoride, hexaniobium undecylfluoride, niobium(III) fluoride, niobium(IV) fluoride, niobium(V) fluoride, nickel(II) fluoride, neptunium(III) fluoride, neptunium(IV) fluoride, platinum(IV) fluoride, platinum(V) fluoride, platinum(VI) fluoride, palladium(II) fluoride, palladium(IV) fluoride, barium fluoride, bismuth(III) fluoride, beryllium fluoride, plutonium(III) fluoride, Beryllium fluoride, holmium(III) fluoride, magnesium fluoride, manganese(II) fluoride, manganese(III) fluoride, manganese(IV) fluoride, molybdenum(II) fluoride, molybdenum(III) fluoride, molybdenum(IV) fluoride, europium(II) fluoride, europium(III) fluoride, lanthanum fluoride, lithium fluoride, ruthenium(II) fluoride, ruthenium(III) fluoride, rubidium fluoride, rhenium (IV), rhenium(V) fluoride, rhenium(VI) fluoride, rhenium(VII) fluoride, rhodium(III) fluoride, rhodium(IV) fluoride, rhodium(V) fluoride, rhodium(VI) fluoride and the like;

[0033]

metal chlorides such as zinc(I) chloride, zinc(II) chloride, aluminum chloride, antimony(III) chloride, antimony(IV) chloride, yttrium(III) chloride, iridium(I) chloride, iridium(II) chloride, iridium(III) chloride, iridium(IV), indium(I) chloride, indium(II) chloride, indium(III) chloride, uranium(III) chloride, uranium(IV) chloride, uranium(V) chloride, uranium(VI) chloride, osmium(III) chloride, osmium(IV) chloride, osmium(V)

chloride, cadmium(II) chloride, potassium chloride, gallium(I) chloride, gallium(II) chloride, gallium(III) chloride, calcium chloride, gold(I) chloride, gold(III) chloride, gold dichloride, silver chloride, chromium(II) chloride, chromium(III) chloride, chromium(IV) chloride, cobalt(II) chloride, mercury(I) chloride, mercury(II) chloride, scandium chloride, tin(II) chloride, tin(IV) chloride, strontium chloride, cerium(III) chloride, cerium(IV) chloride, thallium(I) chloride, thallium(III) chloride, thallium dichloride, thallium trichloride, tungsten(II) chloride, tungsten(III) chloride, tungsten(IV) chloride, tungsten(V) chloride, tungsten(VI) chloride, hexatantalum tetradecylchloride, hexatantalum pentadecylchloride, tantalum(III) chloride, tantalum(IV) chloride, tantalum(V) chloride, technetium(IV) chloride, technetium(VI) chloride, iron(II) chloride, iron(III) chloride, copper(I) chloride, copper(II) chloride, thorium(IV) chloride, sodium chloride, lead(II) chloride, lead(IV) chloride, hexaniobium undecylchloride, hexaniobium pentadecylchloride, triniobium octachloride, niobium(III) chloridre, niobium(IV) chloride, niobium(V) chloride, nickel(II) chloride, neodymium(II) chloride, neodymium(III) chloride, neptunium(III) chloride, neptunium(IV) chloride, platinum(II) chloride, platinum(IV) chloride, platinum trichloride, palladium(II) chloride, bismuth(III) chloride, praseodymium(III) chloride, plutonium(III) chloride, plutonium(IV) chloride, beryllium chloride, magnesium chloride, manganese(II) chloride, molybdenum(II) chloride,

molybdenum(III) chloride, molybdenum(IV) chloride, molybdenum chloride (V), europium(II) chloride, europium(III) chloride, lanthanum chloride, lithium chloride, ruthenium(III) chloride, rubidium chloride, rhenium(III) chloride, rhenium(IV) chloride, rhenium(V) chloride, rhenium(VI) chloride, rhodium(I) chloride, rhodium(II) chloride, rhodium(III) chloride and the like;

[0034]

metal bromides such as zinc(II) bromide, aluminum bromide, antimony bromide, yttrium bromide, iridium(I) bromide, iridium(II) bromide, iridium(III) bromide, iridium(IV) bromide, indium(I) bromide, indium dichloride, indium(III) bromide, uranium(III) bromide, uranium(IV) bromide, uranium(V) bromide, osmium(III) bromide, osmium(IV) bromide, cadmium(II) bromide, potassium bromide, gallium(I) bromide, gallium dibromide, gallium(III) bromide, calcium bromide, gold(I) bromide, gold(III) bromide, silver bromide, chromium(II) bromide, chromium(III) bromide, mercury(I) bromide, mercury(II) bromide, scandium bromide, tin(II) bromide, tin(IV) bromide, strontium bromide, cesium bromide, cerium(III) bromide, thallium(I) bromide, thallium(III) bromide, tungsten(II) bromide, tungsten(III) bromide, tungsten(IV) bromide, tungsten(V) bromide, tungsten(VI) bromide, hexatantalum tetradecylbromide, hexatantalum pentadecylbromide, tantalum(III) bromide, tantalum(IV) bromide, tantalum(V) bromide, iron(II) bromide, iron(III) bromide, triiron octabromide, copper(I) bromide, copper(II) bromide, thorium(IV) bromide, sodium bromide, lead(II)

bromide, hexaniobium tetradecylbromide, triniobium octabromide, niobium(III) bromide, niobium(IV) bromide, niobium(V) bromide, nickel(II) bromide, neptunium(III) bromide, neptunium(IV) bromide, platinum(II) bromide, platinum(IV) bromide, platinum tribromide, palladium(II) bromide, barium bromide, bismuth bromide, plutonium(III) bromide, beryllium bromide, magnesium bromide, manganese(II) bromide, molybdenum(II) bromide, molybdenum(III) bromide, molybdenum(IV) bromide, europium(II) bromide, europium(III) bromide, lanthanum bromide, lithium bromide, ruthenium(II) bromide, ruthenium(III) bromide, rubidium bromide, rhenium(III) bromide, rhenium(IV) bromide, rhenium(V) bromide, rhodium(II) bromide, rhodium(III) bromide and the like;

[0035]

metal iodides such as zinc(II) iodide, aluminum iodide, diantimony tetraiodide, antimony(III) iodide, yttrium iodide, iridium(I) iodide, iridium(II) iodide, iridium(III) iodide, iridium(IV) iodide, indium(I) iodide, indium(III) iodide, uranium(II) iodide, uranium(IV) iodide, osmium(I) iodide, osmium(II) iodide, osmium(III) iodide, cadmium iodide, potassium iodide, gallium(I) iodide, gallium(III) iodide, calcium iodide, gold(I) iodide, gold(III) iodide, silver iodide, titanium(III) iodide, chromium(II) iodide, chromium(III) iodide, cobalt(I) iodide, cobalt(III) iodide, mercury(I) iodide, mercury(II) iodide, scandium iodide, tin(II) iodide, tin(IV) iodide, strontium iodide, cesium iodide, cerium(II) iodide, cerium(III) iodide, thallium(I)

iodide, thallium(III) iodide, tungsten(II) iodide, tungsten(III) iodide, tungsten(IV) iodide, tungsten(V) iodide, tungsten(VI) iodide, iron(II) iodide, iron(III) iodide, triiron octaiodide, copper(I) iodide, copper(II) iodide, thorium(IV) iodide, sodium iodide, lead(II) iodide, hexaniobium tetradecyliodide, triniobium octaiodide, niobium(III) iodide, niobium(IV) iodide, niobium(V) iodide, nickel(II) iodide, neptunium(III) iodide, neptunium(IV) iodide, platinum(II) iodide, platinum(IV) iodide, platinum triiodide, palladium(II) iodide, barium iodide, bismuth(III) iodide, plutonium(III) iodide, beryllium iodide, magnesium iodide, manganese(II) iodide, molybdenum(II) iodide, molybdenum(III) iodide, molybdenum(IV) iodide, europium(II) iodide, europium(III) iodide, lanthanum iodide, lithium iodide, ruthenium(II) iodide, ruthenium(III) iodide, rubidium iodide, rhenium(III) iodide, rhenium(IV) iodide, rhenium(V) iodide, rhodium(II) iodide, rhodium(III) iodide and the like.

The metal halide is preferably sodium chloride, sodium iodide, magnesium chloride, manganese(II) chloride, iron(II) chloride or nickel(II) bromide.

[0036]

When the catalyst for polymerization of the present invention is used, the amount of the organoaluminum compound (A) used can be selected from a wide range in which the concentration of the organoaluminum compound (A) in the polymerization system is usually $10^{-6}$ to 10 mol/l. A range of from $10^{-5}$ to 1 mol/l is preferable.

[0037]

The amount of the boron compound (B) is used at an amount in which a molar ratio of the organoaluminum compound (A) to the boron compound (B) [(A)/(B)] is usually from 0.1 to 10000 and preferably from 0.5 to 5000.

[0038]

The amount of the solid inorganic compound (C) used can be selected at a wide range in which the concentration of the solid inorganic compound (C) in the polymerization system is usually 0.001mg/l to 1000g/l. The preferable range is from 0.01mg/l to 100g/l.

[0039]

As the method of supplying the respective components in a polymerization vessel, for example, they are supplied in an inert gas such as nitrogen, argon or the like under a moisture free condition. The catalyst components (A), (B) and (C) may be separately fed, or may be fed after previously contacting.

[0040]

The polymerization is usually carried out at a temperature of from -80℃ to 300℃, preferably from -40℃ to 280℃, and more preferably from 20℃ to 250℃.

The polymerization pressure is not particularly limited, and the pressure range is preferably from normal pressure to about 150 atm. from industrial and economical viewpoints. In general, the polymerization time is appropriately determined depending on kinds of a desired polymer and a reaction apparatus, and the range is usually from 1 minute

to 40 hours.

[0041]

In the polymerization process, Either of a continuous process and a batch-wise process are possible. Further, a slurry polymerization or a solvent polymerization in which a hydrocarbon solvent such as propane, pentane, hexane, heptane, octane, toluene or xylene, is used, a liquid phase polymerization without using a solvent, or a gas phase polymerization can be conducted.

[0042]

The process for producing an α-olefin polymer of the present invention is a process for producing an α-olefin polymer using the above-mentioned catalyst for α-olefin polymerization, it is preferably suitable for a process for producing a stereoregular α-olefin polymer, particularly, for a process for producing an isotactic stereoregular α-olefin polymer.

[0043]

Herein, the stereoregular α-olefin polymer means a α-olefin polymer in which alkyl groups as side chains exist at sterically regular positions to the backbone formed of carbon-carbon bonds, and in the case of isotactic stereoregularity, the steric structure is an isotactic structure, namely it has a steric structure in which alkyl groups as side chains are positioned at the same side to the backbone formed of carbon-carbon bonds.

The tacticity is determined by $^{13}$C-NMR method, and can be shown by the existence ratio of a plural number of successive

constitution units. Wherein the isotactic stereo-regular $\alpha$-olefin polymer is an $\alpha$-olefin polymer in which an isotactic diad ratio [mm] being two successive constitution units exceeds 0.25. In the production process, the [mm] of an $\alpha$-olefin polymer produced is preferably is 0.40 or more, and more preferably 0.50 or more.

[0044]

As an $\alpha$-olefin applied to polymerization of the present invention, an $\alpha$-olefin having 3 to 20 carbon atoms is preferable. Specific examples of thereof include linear chain olefins such as propylene, 1-butene, 1-pentene, 1-hexene, 1-heptene, 1-octene, 1-nonene, 1-decene and the like, branched olefins such as 3-methyl-1-butene, 3-methyl-1-pentene, 4-methyl-1-pentene and the like, but the present invention should not be limited to the above-mentioned compounds.

[0045]

In the process for producing an $\alpha$-olefin polymer of the present invention, it is possible to copolymerize an $\alpha$-olefin with another olefin and/or another polymerizable unsaturated compound.

In such copolymerization, 50 mol % or more of the $\alpha$-olefin is preferably copolymerized.

[0046]

Herein, as another olefin, ethylene, $\alpha$-olefins having 3 to 20 carbon atoms, and diolefins having 4 to 20 carbon atoms can be used, and two or more of olefins can be simultaneously used.

Specific examples of the olefin include linear chain olefins such as propylene, 1-butene, 1-pentene, 1-hexene, 1-heptene, 1-octene, 1-nonene, 1-decene and the like; branched olefins such as 3-methyl-1-butene, 3-methyl-1-pentene, 4-methyl-1-pentene and the like; vinylcyclohexane and the like, but the present invention should not be limited to the above-mentioned compounds.

[0047]

Further, other polymerizable unsaturated compounds, acrylic acid ester compounds, methacrylic acid ester compounds and alkenyl aromatic hydrocarbons are listed.

[0048]

Specific examples of the acrylic acid ester compounds include methyl acrylate and compounds in which the methyl group thereof is replaced with ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl or the like, and specific examples of the methacrylic acid ester compounds include methyl methacrylate and compounds in which the methyl group thereof is replaced with ethyl, n-propyl, isopropyl, n-butyl, isobutyl, tert-butyl or the like.

[0049]

As the alkenyl aromatic hydrocarbon compounds, an alkenyl compound having an aromatic hydrocarbon group having 6 to 25 carbon atoms is preferable. Specific examples of the aromatic hydrocarbon group having 6 to 25 carbon atoms include a phenyl group, tolyl group, xylyl group, tert-butylphenyl group, vinylphenyl group, naphthyl group, phenanthryl group, anthracenyl group and the like. A phenyl group, tolyl group,

xylyl group, tert-butylphenyl group, vinyl phenyl group and naphthyl group are preferable.

Specific examples of the alkenyl aromatic hydrocarbon include alkenylbenzenes such as styrene, 2-phenylpropylene, 2-phenylbutene and the like; alkylstyrenes such as p-methylstyrene, m-methylstyrene, o-methylstyrene, p-ethylstyrene, m-ethylstyrene, o-ethylstyrene, 2,4-dimethylstyrene, 2,5-dimethylstyrene, 3,4-dimethylstyrene, 3,5-dimethylstyrene, 3-methyl-5-ethylstyrene, p-tert-butylstyrene, p-sec-butylstyrene and the like; vinylnaphthalenes such as 1-vinylnaphthalene and the like, etc.

[0050]

Specific examples of the combination of monomers constituting copolymers produced by the production process of $\alpha$-olefin polymers of the present invention, include

propylene and 1-butene, propylene and 1-hexene, propylene and 1-octene, 1-butene and 1-hexene, and the like, but the present invention should not be limited to these combinations.

[0051]

Further, in order to control the molecular weight of the $\alpha$-olefin polymer obtained, a chain transfer agent such as hydrogen, a silane compound or the like can be added.

[0052]

[EXAMPLE]

The present invention is further illustrated in detail according to Examples below, but the present invention is not limited thereto.

Further, the measurement values of respective items in Examples were measured according to methods described below.

[0053]

(1) Weight average molecular weight (Mw), number average molecular weight (Mn), and molecular weight distribution (Mw/Mn):

They were measured under the following conditions according to a gel permeation chromatography (GPC). Further, calibration curve was prepared using a standard polystyrene.

Machine: 150CV type, manufactured by Milipore Waters Co., Ltd.

Column: Shodex M/S 80

Measurement temperature: 145℃

Solvent: O-dichlorobenzene

Sample concentration: 5 mg/8 ml

The molecular weight distribution was evaluated as a ratio of Mw to Mn(Mw/Mn).

[0054]

(2) Melting point (Tm: ℃)

It was measured using DSC-VII manufactured by Perkin Elmer Co., Ltd. according to the conditions below.

Heating: 40℃ to 220℃(5℃/min.),
retaining for 5 minutes.

Cooling: 220℃ to 150℃(300℃/min.),
retaining for 1 minute.

Cooling: 150℃ to 50℃(5℃/min.),
retaining for 1 minute.

Measurement: 50℃ to 180℃(raised at 5℃ /min.)

[0055]

(3) Stereo-regularity

$^{13}$C-NMR was measured according to the conditions below using AM400 manufactured by Bruker Co., Ltd., and the stereo-regularity was calculated according to a peak area ratio of a methyl group.

Solvent: O-dichlorobenzene/deuterated benzene =4/1 (volume ratio)

Concentration: 10 mg/0.6 ml

Temperature: 135℃

[0056]

The respective compounds used at polymerization in Examples described below are below.

・Triisobutylaluminum: commercially available product manufactured by Toso-Akzo Co., Ltd. Triisobutylaluminum was diluted with toluene to be used as a 1M solution.

・Triphenylcarbenium tetrakis(pentafluorophenyl) borate: commercially available product manufactured by Toso-Akzo Co., Ltd. was dried under vacuum at 150℃ for 4 hours, and then used.

・Manganese(II) chloride (manufactured by Aldrich Co., Ltd., purity=99.999%) and magnesium chloride(II) (manufactured by Junsei Chemicals Co., Ltd., purity=99.99%) were milled under nitrogen atmosphere using an agate mortar.

[0057]

[Example 1]

Under nitrogen atmosphere, 25mg (0.2mmol) of manganese(II) chloride, 184mg of triphenylcarbenium

tetrakis(pentafluorophenyl)borate, and 5ml of purified toluene were charged in a 100ml autoclave made of stainless. Thereto, 1ml (1mmol) of triisobutylaluminum was added, the autoclave was cooled using dry ice, and 40g of propylene was charged. Then, the mixture was reacted at 35℃ for 3 hours in an oil bath. The unreacted propylene gas was purged, the content of the autoclave was charged in 100ml of ethanol into which 5ml of 3N hydrochloric acid was added, a polymer precipitated was separated by filtration, and drying was carried out at 80℃ for about 4 hours. As a result, 53mg of a polypropylene was obtained. The weight average molecular weight (Mw) of the polypropylene obtained was 541000, and molecular weight distribution (Mw/Mn) was 9.9. Concerning stereo regularity, [mm] was 0.63, [mr] was 0.20, and [rr] was 0.17. Melting point (Tm) was 144℃.

[0058]

[Example 2]

Polymerization was carried out in the same manner as in Example 1, except that manganese(II) chloride was changed to 19mg (0.2mmol) of magnesium chloride. As a result, 68mg of a polypropylene was obtained. The weight average molecular weight (Mw) of the polypropylene obtained was $21.9 \times 10^6$, and molecular weight distribution (Mw/Mn) was 4.6. Concerning stereoregularity, [mm] was 0.57, [mr] was 0.23, and [rr] was 0.20. Melting point (Tm) was 147℃.

[0059]

[Comparative Example 1]

Polymerization was carried out in the same manner as in

Example 1, except that triphenylcarbenium tetrakis(pentafluorophenyl)borate was not added. As a result, a polymer was hardly obtained.

[0060]

[Effect of the Invention]

As described above in detail, according to the present invention, a catalyst for $\alpha$-olefin polymerization which reveals a high polymerization activity, and a process for producing efficiently an $\alpha$-olefin polymer are provided. A high polymerization activity can be revealed according to the present invention without using a conventional solid catalyst component (a solid catalyst component in which a titanium atom, a halogen atom and an electron donor are essential components), a transition metal compound such as a metallocene complex or the like which has been considered as essential for revealing a high polymerization activity, and an $\alpha$-olefin polymer having a stereoregularity can be produced, therefore the value of the present invention is extremely great.

[Document Name] ABSTRACT

[Abstract]

[Subject] To provide a catalyst for $\alpha$-olefin polymerization showing a high polymerization activity and a process for producing efficiently an $\alpha$-olefin polymer.

[Solution means]

A catalyst for $\alpha$-olefin polymerization obtained by contacting (A), (B) and (C) described below, and a process for producing an $\alpha$-olefin polymer with the catalyst:

(A) an organoaluminum compound,

(B) one or more of boron compounds selected from (C1) to (C3) below;

(B1) a boron compound represented by the general formula $BQ^1Q^2Q^3$,

(B2) a boron compound represented by the general formula $G^+(BQ^1Q^2Q^3Q^4)^-$, and

(B3) a boron compound represented by the general formula $(L-H)^+(BQ^1Q^2Q^3Q^4)^-$.

(wherein B is a boron atom, $Q^1$ to $Q^4$ are a halogen atom, a hydrocarbon group, a halogenated hydrocarbon group, a heterocyclic group, a substituted silyl group, an alkoxy group, or a di-substituted amino group, and they may be the same or different; $G^+$ is an inorganic, organic or organometallic cation; L is a neutral Lewis base, and $(L-H)^+$ is a Brφnsted acid.), and

(C) a solid inorganic compound.

[Selected Drawing] None

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